B737NG Alerting Issues – Loss/degradation of GPS

1. Initiating Condition: Poor GPS satellite availability or geometry leading to decreased GPS signal integrity

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	Text Alert "Unable Reqd Nav Perf-RNP" on FMS CDU scratchpad	ANP>RNP	Meaning of text can be unclear	Text messages on FMS scratchpad can be inadequately salient. Also, once cleared by pilot action, they may not be re-displayed		When ANP<RNP
	"FMC" amber annunciation on forward panel	Driven by UNABLE REQD NAV PERF-RNP message	Meaning of alert can be unclear			When ANP<RNP
	"Msg" amber alert on FMS CDU	Driven by UNABLE REQD NAV PERF-RNP message		Text messages on FMS scratchpad can be inadequately salient. Also, once cleared by pilot action, they may not be re-displayed		When ANP<RNP
	PFD/EADI Navigation Performance Scales/ANP Bars flash first 10 seconds of exceedence, turn amber if exceeded 10 seconds (if installed)	ANP>RNP				When ANP<RNP
	RNP/ANP alphanumeric under airplane symbol turns amber (if installed)	ANP>RNP				
	Amber TERR POS annunciation on Nav Display	ANP>RNP (B737 manuals refer to this only as "positional uncertainty" while B777 manuals specify ANP>RNP)	Relationship of these indications to GPS position/updating is not transparent			When ANP<RNP

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Visual Alerts	RAIM forecast message from dispatch during preflight planning or update inflight via ACARS	Inadequate satellite availability/ geometry as detected by RAIM forecast analysis performed by dispatch (inflight update can be generated by dispatch or requested by pilots)		May not be provided before flight if RNP approach not anticipated		
Aural Alerts	None					
Tactile Alerts	None					
Visual Cues	ANP value greater than RNP value on CDU legs/progress page		Meaning of text can be unclear			When ANP<RNP
Aural Cues	None					
Tactile/ Somatic Cues	None					

B737NG Alerting Issues – Loss/degradation of GPS

1. Initiating Condition: Poor GPS satellite availability or geometry leading to decreased GPS signal integrity – Cont.

Expected Pilot Response(s)

- Perform procedure for UNABLE REQD NAV PERF-RNP.
- Return to ground-based navigation, if any, as directed by the NNP.
- During RNP approach, execute missed approach (also directed by the NNP but timely response is required so may not be able to wait for checklist).

How does pilot know condition is resolved/recovered?

- Lookup of FMS CDU page displaying ANP/ RNP; inspection of ANP/RNP values.

Issues with regard to multiple concurrent non-normal conditions

- Loss of terrain clearance warning.
- False terrain clearance warning.
- Loss of separation from air traffic (ADS or NextGen navigation/surveillance).

B737NG Alerting Issues – Loss/degradation of GPS

2. Initiating Condition: Intentional spoofing (intentional introduction of false position into the GPS receiver) leading to false position input from GPS to the FMS

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	"VERIFY POSITION-FMC-GPS. IRS-FMC or FMC-RADIO" alert on FMS CDU scratchpad (U10.8 software only)	GPS position differs from IRS, Radio, and/or mixed-source FMS position	Meaning of text can be unclear.	Text messages and alerts on FMS scratchpad can be inadequately salient. Also, once cleared they may not be re-displayed. Alerting and cueing depends on continued operation of multi-mode navigation, with at least inertial position inputs. The alerting threshold for "VERIFY POSITION" likely far exceeds RNP values for all but Oceanic procedural separation, so these alerts may be of limited safety value in current RNP or future Next Gen operations.		When position difference has been reduced to within limits or the inaccurate position source has been manually deselected from the FMS solution
	MSG amber annunciation on FMS CDU	Driven by VERIFY POSITION message				
	"FMC" amber alert on forward panel	Driven by VERIFY POSITION message				
	PFD/EADI Navigation Performance Scales/ANP Bars flash first 10 seconds of exceedence, turn amber if exceeded 10 seconds (if installed)	Only presented in subset of conditions in which calculated ANP>RNP				When ANP<RNP

B737NG Alerting Issues – Loss/degradation of GPS

2. Initiating Condition: Intentional spoofing (intentional introduction of false position into the GPS receiver) leading to false position input from GPS to the FMS – cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	RNP/ANP alphanumeric under airplane symbol turns amber (if installed)	Only presented in subset of conditions in which calculated ANP>RNP				
Aural Alerts	None					
Tactile Alerts	None					
Visual Cues	ANP value greater than RNP value on CDU legs/progress page	Only presented in subset of conditions in which calculated ANP>RNP	Meaning of text can be unclear.			When ANP<RNP
	Possible visible map shift, if the system makes a position change or correction while a pilot is looking at the navigation display		Map shift, if it occurs, may not be noticed, or if noticed the caused will be unclear and it will not be evident whether the shift was to a more or less accurate position. In the absence of map shift and FMS text alerts there will be no alerting or cueing to false position.			
Aural Cues	None					
Tactile/ Somatic Cues	None					

B737NG Alerting Issues – Loss/degradation of GPS

2. Initiating Condition: Intentional spoofing (intentional introduction of false position into the GPS receiver) leading to false position input from GPS to the FMS – cont.

Expected Pilot Response(s)

- Verify position using alternative means (e.g. radar, DME).
- Identify false information.
- Eliminate source of false information from the position solution.

Possible sources of confusion with regard to pilot response(s)

- Without effortful investigation it may not be clear to the pilot which of the navigation sources is/are providing the false position; also, because of the normally high accuracy of GPS pilots tend to believe its information and downplay the other sources. This is particularly the case because the FMS are programmed to heavily weight the GPS position in calculating the mixed-source FMS position solution, because of the normal great accuracy of GPS. As a result, the FMS position may drift or shift into a false position that may appear, to the pilots, to be a malfunction of the IRS or Radio position sources.

How does pilot know condition is resolved/recovered?

- Verifying position after reverting to alternative navigation.

Issues with regard to multiple concurrent non-normal conditions

- Loss of terrain clearance warning.
- False terrain clearance warning.
- Loss of separation from air traffic (ADS or NextGen navigation/surveillance).